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FOREST SERVICE

School of Forestry
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LAKE STATES FOREST EXPERIMENT STATION

REPORT TO THE ADVISORY COMMITTEE

FOR 1930

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LAKE STATES FOREST EXPERIMENT STATION°

REPORT TO THE ADVISORY COMMITTEE FOR

1930

SUMMARY

What the Station Has Done in 1930

1. "Forest Fires in Michigan", a statistical analysis of past fire records in that State is now in page proof. It will be off the press before this report is distributed.

2. A manuscript on slash disposal as a fire protective and silvicultural measure in Wisconsin was prepared in cooperation with the Wisconsin Conservation Commission and University of Minnesota. It is now in press and will come out as a publication of the Wisconsin Agricultural Experiment Station.

3. The results of the first phase of the erosion study, carried on in cooperation with the University of Wisconsin in the non-glaciated part (Southwestern corner) of that State, were published in "Soil Erosion - a local and a national problem", University of Wisconsin Agricultural Experiment Station Research Bulletin 99.

4. A report entitled "Aspen Availability, Properties and Utilization", written in cooperation with the Forest Products Laboratory and the Division of Forestry, University of Minnesota, was published as University of Minnesota Agricultural Experiment Station Technical Bulletin 70.

5. Volume and yield tables for second-growth white pine were published in "Second-Growth White Pine in Wisconsin - Its Growth, Yield and Commercial Possibilities", University of Wisconsin Agricultural Experiment Station Research Bulletin 98.

6. "Selective Logging in the Northern Hardwoods of the Lake States", by R. Zon and R. D. Harver, was published as U. S. Department of Agriculture Technical Bulletin 164.

7. As a result of a joint study between the Station and the Division of Soils, University of Minnesota, on leaf litter, a paper "The Quantity and Nutrient Contents of Pine Leaf Litter", by Dr. F. J. Alway and R. Zon, was published in the May, 1930, Journal of Forestry.

8. A 16-page pamphlet, "The Upper Peninsula Forest Experiment

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°Maintained by the U. S. Department of Agriculture at St. Paul, Minnesota, in cooperation with the University of Minnesota.

Station: What It Is - What It Does", published by the Upper Peninsula Development Bureau, describes the activities and research underway at the Upper Peninsula Experimental Forest.

9. As a result of the study of Norway pine seed production, a report entitled "A New Principle in Seed Collecting for Norway Pine" has been submitted to the Journal of Forestry for publication.

10. A report presenting evidence tending to show that the bird's-eye character of maple results from suppression, or in other words, from unfavorable growing conditions, has been prepared and submitted to the Journal of Forestry for publication.

11. Two reports, based on preliminary investigations on the possibilities of forest planting in the sand hills, and of windbreak establishment in North Dakota, outlined the need for more intensive studies. As a result Congress has appropriated $15,000 for thorough studies of these problems.

12. A reconnaissance study of the erosion problem in the Bad Lands of North Dakota was made and a report written.

13. About 600 miles of strip surveys were run in cooperation with the State Land Economic Surveys in Michigan, Wisconsin and Minnesota.

14. A Forest Fire Research Station was established near Roscommon, Michigan, in cooperation with the Conservation Commission of that State. It has now been in operation one complete season.

15. Thirty acres of virgin hardwoods at the Upper Peninsula Experimental Forest near Dukes, Michigan, were logged to determine the effect of new methods of cutting. A total of 116 acres have now been cut over in various experiments.

16. Improvement cuttings were made, blank spaces planted, and young stands put under more favorable growing conditions on an additional 5 acres on the Upper Peninsula Experimental Forest.

17. The seed-control station, installed at University Farm in the fall of 1929, has now been in active operation over one year. Some 400 germination tests, started in the fall of 1930, will be completed in the spring of 1931, about 40 of these which are of commercial seed samples.

18. The Station, in cooperation with Wisconsin Conservation Commission, has practically completed a study of the growth on cut-over pine and swamp lands registered under the forest crop tax law of that State. The results will be available early in 1931.

19. Twenty-three volume tables were completed.

20. Twenty-two new permanent sample plots were established, three were remeasured, and counts were made on reproduction strips of thirteen others.

21. Twenty-one technical notes were prepared and distributed, and some 15 articles were published in various journals and magazines.

22. About 25 addresses and lectures were given by members of the staff.

23. 5500 letters were handled during the year.

What The Station Is Working On

1. Forest Fire Damage: Physical damage to existing stands and the effect of fire on soil and growth. Michigan, Wisconsin and Minnesota.

2. Behavior of fires under various conditions of weather, topography, cover, and fuels. Michigan, Wisconsin and Minnesota.

3. Fire Fighting Methods and Equipment: Effectiveness and practicability of various methods of fire suppression and different kinds of equipment. In cooperation with Michigan Conservation Commission at Roscommon Forest Fire Research Station.

4. Fire Breaks and Lines: Effectiveness of various kinds of fire lines and the cost of their construction and maintenance. In cooperation with Michigan Conservation Commission at Roscommon Forest Fire Research Station.

5. Forest Fire Fuels: Determination of the inflammability of characteristic forest fire fuels in relation to weather conditions, type and density of cover. Michigan, Wisconsin and Minnesota.

6. Use of Chemicals in Fire Control: Effectiveness of various chemicals in suppressing or checking fires and in keeping fire lines free of vegetation. In cooperation with Michigan Conservation Commission at Roscommon Forest Fire Research Station.

7. Forest Fire Weather: Relation between occurrence and spread of fires and weather as a basis of predicting fire weather. In cooperation with the U. S. Weather Bureau. Michigan, Wisconsin and Minnesota.

8. Slash Disposal - jack pine and oak: Effectiveness and cost of different methods of slash disposal.

9. Selective Logging in Northern Hardwoods: Practicability of partial versus clear cutting; the results of various degrees of partial

cutting; the cost of logging under present and selective cutting systems. Northeastern Wisconsin and the Upper Peninsula of Michigan.

10. Woodlot Management: With special emphasis upon the demonstration of proper methods of handling woodlots. In cooperation with the Wisconsin Forest Extension Specialist, Southern Wisconsin.

11. Methods of Cutting Jack Pine to Promote Its Conversion to More Valuable Conifers: Chippewa and Superior National Forests.

12. Thinning Young Norway Pine Stands: Chippewa National Forest.

13. Thinning Jack Pine Stands: Chippewa National Forest.

14. Natural Reproduction of Norway Pine on the Michigan Sand Plains: Huron National Forest.

15. Methods of Cutting Norway Pine Stands: Chippewa National Forest.

16. Determination of the Most Satisfactory Method of Slash Disposal for Jack Pine: Michigan.

17. Effort of Water Level in Swamps on Forest Growth: Upper Peninsula of Michigan and Chippewa National Forest.

18. Conversion of Inferior Stands into More Valuable Forests: Natural and Artificial Regeneration. Chippewa and Superior National Forests and the Upper Peninsula of Michigan.

19. Effect of Oak Cover on Pine Plantations. In cooperation with the University of Michigan. Lower Peninsula of Michigan.

20. Reforestation: Improved reforestation methods; seed storage; pretreatment of white pine seed; grading of seed.

21. Seed Production of Norway Pine: In cooperation with the Cloquet Forest Experiment Station. Cloquet Experimental Forest.

22. Tree Breeding: Effect of seed source on suitability of trees for planting; differentiation of growth zones based on climatic factors; planting of bird's-eye maple; forms of Scotch pine.

23. Fundamental Laws Underlying the Development of Stands.

24. Causes of Soil Erosion and its Control by Forest Planting and Engineering Works.

25. Correlation of Soil Types, Plant Indicators and Forest Types and Sites. Minnesota, Wisconsin and Michigan.

26. Effect of Physical Factors, Especially Light, on the Establishment and Early Growth of Conifers under Canopies. Chippewa National Forest and Upper Peninsula Branch Station.

27. Forest Survey: Determination of amount of forest material; present rate of growth and possible increases; drain upon forests by cutting, fire, etc.; and the wood requirements of the three Lake States.

28. Relation of Animal and Bird Life to Forest Production in Cooperation with Biological Survey. Minnesota, Wisconsin and Michigan.

New Investigations Planned for 1931

1. Intensive studies on the possibilities of forest planting in the sand hills, and of windbreak establishment in North Dakota, will be started.

2. An economic study of the "New Public Domain" (the millions of acres of land which are reverting to public ownership through delinquent taxes) will be undertaken.

3. Out of the soil erosion studies conducted in southwestern Wisconsin the last 2 years, in cooperation with the University of Wisconsin, there has now emerged a permanent soil erosion station. In this station the Forest Service, the Bureau of Chemistry and Soils, the Bureau of Public Roads, and the University of Wisconsin are to cocperate. The Federal government has made available $15,000 and the University of Wisconsin $10,000 for the conduct of the study during the fiscal year 1931-32.

4. An experimental forest will be selected and development started on the Superior National Forest.

5. Efforts will be renewed to determine upon a satisfactory location for the Wisconsin Branch. The Station will cooperate with the Regional Forester with a view to locating on one of the new Wisconsin purchase units. This sub-station will have for its main purpose the investigation of problems encountered in growing raw material for the pulp and paper industry.

6. Cooperation with the state land economic surveys will be continued on an enlarged scale.

ORGANIZATION

The Federal appropriation for the Experiment Station increased during the calendar year 1930 from $56,163.89 to $78,505.45. An additional amount of $7,950.00 was obtained through State cooperation,

making the total budget $86,455.45. This allowed some expansion in the economics research, especially the Forest Survey. During the year the Station personnel numbered over 50, of which 19 were permanent employees.

ECONOMIC APPLICATION OF FOREST RESEARCH

The acid test of any research is the degree to which its results help to understand life, and contribute to the guidance of the activities of the private and public agencies, States and Government. It has been the policy of the Station, during the eight years of its existance, to attempt investigations which contribute directly to the solution of the most pressing problems.

The whole field of forestry is still going through an adjustment to the rapidly developing economic changes in the region. Forestry is still permeated with economic considerations such as conflicting ideas of land use, rapidly increasing tax delinquency, shortage of certain forest products, like spruce pulpwood, overproduction and surplus of other products, rising taxes, competition with the Pacific coast, and even European countries. All these leave an impress upon forest investigation. What, for instance, agitates and affects the public mind in the Lake States? Is it the technique of planting, the drought resistance of different kinds of trees, the light and soil requirements of our forest trees, methods of thinning? These problems have a place in the research work of the Station, but that is not what the public is most interested in. What the public wants to know is, what can be done with the cut-over lands of the region? Should they be turned into productive forests, developed as recreational areas, or used for propagation of game? How can the abandonment of cut-over land be stopped? Can forest tax laws prevent the flow of land into public ownership? How will such laws affect the finances of local communities? Can zoning help the situation? What kind of a tax can cut-over land stand? Is agriculture likely to take up much cut-over land? How much commercial forest still remains in the region? What is the present growth on the forest land? What is the future of lumber? These, and similar questions, occupy the mind of the public and it is naturally looking toward the Station for kelp in reaching an answer.

No matter what investigation the Station may undertake, it inevitably comes to the economics of the situation.

The forest economic problems occupy, therefore a prominent place in the investigative program of the Station and give practical significance to most of its projects. But, forestry and biological problems are not being overlooked for they, after all, are the basis for sound economic policies. How can one determine, for instance, whether private forestry is possible without knowing how fast timber grows under various conditions? How can forest planting be advocated if we do not know what seed to obtain, how to store it, how to raise the young trees, and how to plant

them most successfully. How can an intelligent plan of fire protection be devised if no statistics exist as to the seasons when fires occur, the causes of fires and the general climatic and forest conditions which increase or lessen the fire hazard?

Integrated Studies

Some perspective of the whole forest problem can be gained from the following brief facts for the Lake States:

1. 6,000,000 acres of deforested land out of a gross forest area of 58,000,000 acres.

2. 20,000,000 acres of aspen on soil which once produced spruce, white pine, maple and birch timber.

3. 10,000,000 acres of undrained swamp.

4. 15,000,000 acres of woodlots mostly poorly developed and unproductive.

5. 20,000,000 acres of tax delinquent cut-over land.

6. one-fourth the paper and pulp industry of the United States facing an imminent shortage of suitable pulpwood.

7. A huge furniture industry already importing large quantities of wood.

8. A summer tourist industry worth around a third of a billion dollars annually.

To get further into these quantitative facts, and to build the studies around the most pressing problems which exist on the ground, the Station is attempting this year to integrate a number of its economic silvicultural, ecological and mensuration studies. The forest survey is a good meeting ground for these various studies and brings into focus the converging rays of the studies of the rate of growth under various natural conditions, relation of forest types to soil, effect of soils upon rate of growth, different methods of predicting growth, making volume tables, etc. In other words, such studies of soils, types, mensuration and timber quantities, all dovetail toward the solution of one big problem.

The combined surveys also provide a meeting ground with scientific soil, forestry and economic work being carried on by the States.

Recreational Use of Forest Land

The Station has sometimes been criticized for not giving more prominence to recreational use as a factor in economic rehabilitation. If it were to be swayed altogether by popular acclaim it would have to emphasize this feature and undoubtedly would gain some popularity and temporary support by devoting most of its attention to these phases of land use. Just now much faith is put in the development of cut-over lands for recreational purposes, and using land for hunting, fishing and propagation of small and large game. The feeling of the Station staff is that a forester's best contribution to the entire recreation movement is in the rehabilitation of the forests where people will enjoy having their outings, where birds and game will naturally abound, and clear cool streams may have their incidence.

A contribution which the Station can give to the recreational movement is to guide it through economic studies into sound and permanent channels. There is danger that if the recreational movement is left to private initiative and enthusiasts it may be over-developed just as agriculture was over-developed a dozen years ago, and will leave in its wake the same disallusionment. Recreation must not be separated from forestry and best recreational possibilities can be built only on a background of green forests. Forestry, therefore, will still be the main field of investigation of this Station, as it believes with the biblical maxim "Do this thing and all things will be added unto you."

BRANCH STATIONS

The field work of the Station, aside from independent studies, such as the Forest Survey, growth studies, etc., which necessitate going over a wide territory, is now centered at 5 branch stations. Three of these, the Chippewa National Forest, the Superior National Forest and the Upper Peninsula Experimental Forest, are Forest Service stations. The other 2 are cooperative branches, one in cooperation with the University of Minnesota at Cloquet, and the other near Roscommon, Michigan, in cooperation with the Michigan Conservation Commission.

During the coming summer 3 new branch stations will be established. One will be located in Wisconsin on one of the newly created National Forests. The establishment of the Wisconsin Branch has been contemplated for a number of years, but until National Forest land was acquired in Wisconsin no good opportunities existed for its establishment.

Another branch station or experimental forest will be located in North Dakota near Towner where the new forestation activities for that state will be centered.

The third new branch will be established somewhere in southwestern Wisconsin to serve as a permanent soil erosion station. It will be a

cooperative station, run jointly by the Forest Service, the Bureau of Chemistry and Soils, the Bureau of Public Roads and the University of Wisconsin. With these 8 centers of work the Station is well provided with representative areas to carry on field work.

PROGRESS TO DATE AND PLANS FOR 1931

Forest Fire Studies

Program of Fire Research

At a meeting of forest fire research men from all parts of the country, held in Madison last year, a program was adopted covering the more important lines of work in need of immediate attention. Briefly it provides for:

1. The analysis of past experience.

2. A study of fire damage.

3. The continuation of fundamental investigations under way, and

4. Case studies, at designated points, to determine the value of promising fire protection methods, technique, equipment, etc.

In the Lake States a start has already been made on the analysis of available forest fire data resulting to date in the prblication, by Minnesota and Michigan, of reports on the forest fire situation in these states. A much more exhaustive analysis covering all three of the Lake States, for the purpose of rounding out and bringing these reports up to date is proposed for 1932, $10,000 being tentatively allotted for this purpose. Plans are also on foot to undertake a study of Fire Damage covering each of the important forest types of the region, to furnish a better basis for fire damage estimates, to aid in the proper direction of protective effort and to provide a sound economic basis for the allocation of protective dunds.

In the mean time, certain fundamental studies are under way and the Lake States Forest Experiment Station is cooperating with the Michigan Department of Conservation in the development and testing of equipment, fire fighting methods, and fire prevention measures.

Current Projects

Specifically, the projects under way at the present time are:

1. A study of fire weather which has for its object the determination of the specific conditions under which forest fires occur; the

rating of these conditions as a basis for judging the degree of hazard that prevails; and, in cooperation with the Weather Bureau, the working out of a method by which hazard can be predicted.

2. A study of forest fire fuels to determine the inflammability of typical fuels under various conditions, the extent to which their condition is determined by the various factors involved; the relation of their condition to each of these factors; and the lag in their adjustment to changing conditions.

3. A study of jack pine and oak slash to determine the cost and effectiveness of different methods of slash disposal, and the results of each in the way of reducing fire hazard, damage to advance growth, effect on reproduction, rate of decomposition, etc.

4. A study of fire behavior to determine therate of spread and the character and intensity of fires under different conditions.

5. A study of forest fire damage to determine by forest types the character and extent of past fire damage; the immediate losses resulting from forest fires; the effect of fire on growth and yield; the character and abundance of natural reproduction following fire; the period required for regeneration; etc.

6. A study of fire fighting methods and equipment.

7. A study to determine the effectiveness and practicability of using chemicals in fighting forest fires, and

8. A study of fire line construction and maintenance.

Although some work was done on all of these projects in 1930 the Fire-Weather, Forest Fire Fuels, and Slash Disposal Studies occupied the bulk of the time of the Federal men assigned to fire investigations. State effort, on the other hand, was devoted primarily to the testing of fire fighting equipment and to a study of fire line construction and maintenance, with special attention to the use of chemical wood killers.

Plans for 1931 contemplate a continuation of the fire weather and forest fire fuel studies along the same lines as last year, with special attention to a study of going fires and fire damage, and a continuation of the work with chemicals, fire fighting equipment and fire lines. Under the present cooperative arrangement with the Michigan Department of Conservation, the State is responsible for the latter projects and the Lake States Forest Experiment Station for the former. Full cooperation on all projects, however, is provided for.

Management of Northern Hardwood Forests

Selective Logging at Upper Peninsula Experimental Forest

Selective logging studies were continued at the Upper Peninsula Experimental Forest near Dukes, Michigan. During the year 30 acres of virgin hardwoods were logged to determine the effect of a new method of cutting. Eighty per cent of the saw-log material was removed in this operation, which represents the heaviest selective cutting yet made. A total of 116 acres have now been cut over in various experiments.

Improvement cuttings, weedings, and plantings were made on an additional 5 acres of cut-over hardwood land. To date 12 acres of this type of land have been placed in more favorable conditions for growth.

The results of some of the earlier cuttings upon reproduction are of interest. For example, an examination of the 1929 "group selection" cutting experiment reveals the presence of from 3000 to 8000 of yellow birch seedlings per acre. Thus it is encouraging to note that one of the objectives of silvicultural treatment -- that of getting a higher percentage of the desirable yellow birch into the new stand -- gives promise of attainment.

A 16-page pamphlet, "The Upper Peninsula Forest Experiment Station: What it Is - What It Does", was published by the Upper Peninsula Development Bureau. It describes the purpose, location, and character of the experimental forest and outlines briefly the nature and purpose of the experiments under way, most of which deal with the management of hardwood forests.

"Selective Logging in the Northern Hardwoods of the Lake States", published as U. S. Department of Agriculture Technical Bulletin 164, summarizes the results of the studies carried on jointly with the Forest Products Laboratory.

Slash Disposal in Wisconsin

Prompted by the need of the Wisconsin Conservation Commission for information upon which to base a slash disposal policy a study of slash disposal was undertaken. It was carried on as a cooperative project, financed in part by the Conservation Commission and the University of Wisconsin.

The present day slashings in Wisconsin are about 90 per cent from hemlock-hardwood logging operations and 10 per cent from pulpwood cuttings in jack pine. Some 540,000 acres of recent slash were located and mapped. These are a troublesome factor in fire protection, but, of course, in no way compare in hazard with the slash of twenty or thirty years ago in white and Norway pine.

An interesting side light of the study was the discovery that there are only about 400,000 acres of virgin timber left in private hands in Wisconsin (the Capper Report showed over two million acres). This last figure is not the result of a very thorough canvas of all possible owners but it covers practically all holdings of any importance and is thought to be close to the true amount.

It was found that of the 35 or so large companies, which have contributed most of the slash that is now on the ground, 16 have closed up and gone out of business in the past 5 years, and that almost an equal number are due to run out of timber in the next 4 or 5 years. At the end of 5 years there will be only a small handful of operating companies cutting virgin hardwood in Wisconsin.

This general situation in regard to standing timber and existing slash makes it evident that drastic slash disposal legislation at this time will be in effect "locking the door after the horse is stolen." There are, however, a number of things which can be done to improve the slash situation. The report on the study, which is now in the press and which will come out as a publication of the Wisconsin Agricultural Experiment Station, suggests as the principal possibilities, (1) cleaning up of slash along highways, railroads, around buildings and adjoining green timber, or preferably, reserving strips of green timber or selectively logged land adjacent to the highways, (2) breaking up the slash areas by fire breaks, utilizing as far as possible such natural barriers as roads, streams, bogs, and logging railroad spurs, (3) construction of rough roads into inaccessible slash areas, (4) precautionary fire prevention measures in logging operations, and (5) intensive fire protection.

The slash disposal project will be considered as completed as soon as the report appears in print. The selective logging studies at the Upper Peninsula Experimental Forest, however, will be continued during 1931 along the same lines as formerly.

Management of Pine Forests

The effect of different degrees of cutting upon reproduction on the permanent sample plots established in 55-year old jack pine on the Chippewa National Forest in 1927 is now becoming evident. Counts of seedlings now present on the plots show that jack pine has increased the most (880 to 1430 per acre) where 80 per cent of the cover was removed, nearly as much (580 to 1370) where half was removed, and the least (600 to 810) where only 30 per cent was removed. Where there was no cutting a decrease from 1000 per acre to 990 has occurred. The results obtained with Norway pine have, on the other hand, been disappointing. Re. reproduction of this species has increased but slightly on all plots.

Cuttings made in a 60-year old jack pine stand on the Superior National Forest in 1927 show the following results

Stand Removed	Reproduction Per Acre					
	Jack Pine		White Pine and Spruce		Aspen, Paper Birch and Balsam Fir	
	1927	1930	1927	1930	1927	1930
Percent	No.	No.	No.	No.	No.	No.
66	0	1200	230	360	100	180
57	0	475	210	360	1380	4870
49	0	130	420	800	1380	2040
None	0	30	790	1000	1800	1000

In general, the greatest increase in all species on these plots has been where the slash was logged rather than burned.

In the cuttings made in 1926 in a 100-year old Norway pine stand on the Chippewa National Forest to encourage its conversion to white pine, by the removal of about one-fourth of the stand, the white seedlings have increase from 3400 to 4300 per acre. Where only 10 per cent of the stand was removed the white pine seedlings increase only from 1320 to 1350. Although the amount of white pine reproduction is now adequate on all plots but the very lightest cutting, the height growth made by the seedlings has averaged less than 1/2 inch a year. A second cutting was, therefore, made removing additional material from all plots. The increase in light thus afforded should stimulate the growth of the reproduction already present and perhaps favor the establishment of additional seedlings.

No radical change in plans is contemplated for this study during 1931, but work will be continued along the same lines as followed during the past several years.

Management of Swamp Forests

Observations of the effect of drainage upon forest growth were continued on two drained swamps, one at the Upper Peninsula Experimental Forest near Dukes, Michigan, and the other at Bena, on the Chippewa National Forest.

Effect of Drought

The annual analysis of the water level readings taken throughout the summer shows new low levels for both swamps during the past season --- -2.50 and -5.25 feet, respectively. While the water table at Dukes was practically back to normal on November 30, with a level of -0.05 feet,

that at Bena was 3.75 feet below normal. The slow rate of recovery in the latter swamp was undoubtedly due to the very low amount of precipitation received in the fall. At Chatham, Michigan, near Dukes, the annual precipitation for 1930 was only 5 inches below normal, the drought breaking in the latter part of August. Such was not the case at Bena, however, where the drought was prolonged well into the late fall. Weather records kept at Leech Lake Dam, about eight miles from the Bena swamp, show that of a normal annual precipitation of 26 inches but 15 inches were received last year.

Effect of Drainage on Growth and Reproduction

Measurements of trees in the swamp at Dukes, which was drained in 1926, bring out the beneficial effect of drainage. All of the 225 black spruce and balsam fir saplings measured showed an increase in rate of height growth since drainage. The increase was particularly evident on trees within one chain of the interior ditch, black spruce and balsam fir showing increases of 87 per cent and 75 per cent, respectively.

Diameter growth of unsuppressed trees of the more important species growing within 150 feet of ditches averaged 76 per cent greater than trees further away. Of these species, diameter growth of white cedar was 92 per cent greater, balsam fir 76 per cent, black spruce 67 per cent and red maple 62 per cent.

No growth measurements have yet been worked up for the Bena swamp. An interesting effect of drainage there, however, is that it has apparently increased the amount of reproduction. An analysis of the 1930 reproduction counts shows that black spruce seedlings, within 75 feet of the drainage ditches, have increased 500 per acre since drainage in 1927. At a greater distance, there has been an increase of only 40 per acre, and in the undrained check swamp there has been no change at all. Other species show a slight increase aftef drainage and a decrease in the undrained swamp.

Records on the 2 swamps will be continued during 1931.

Use and Conversion of Aspen into More Valuable Forest

Aspen is unique among the forests of the Lake States in that there is a large present supply, abundant young growth, and the prospect of an increasing future supply. The present stand of 12 million cords in trees 6 inches and over promises to be supplemented by 25 million cords within 25 years as areas now covered with 3 to 6 inch-trees become merchantable. The present rate of use of aspen will absorb only a fraction of this volume, and if remedial measures are not taken the remainder will be left to rot. One obvious measure is the encouragement of greater

use and the development of new markets for aspen. This was in part the object of the bulletin "Aspen Availability, Properties, and Utilization" prepared cooperatively by the Forest Products Laboratory, the Minnesota Division of Forestry, and the Station, and recently published and distributed as Technical Bulletin 70 of the University of Minnesota Agricultural Experiment Station. It is timely as more and more of the pulp and paper mills are looking for some raw material to supplement the dwindling supply of hemlock and spruce.

Another measure is the conversion of aspen lands to spruce and pine forests by reforestation. Underplantings in aspen show that white pine and white spruce give 35-60 per cent survival during the first three years. Growth is usually 2 to 3 inches per year. Norway pine seems entirely unsuited for such underplanting. Seed spots 4 years old have live white pine on 18 per cent of the spots and live white spruce on 9 per cent of the spots. Light measurements in aspen stands show values of 10 to 25 per cent above the underbrush on uncut stands. Conifers can live and make moderate growth when they receive 25 per cent light, however, at least 60 per cent is required for good growth. Aspen almost invariably has a luxuriant undergrowth of various shrubs, ferns, and herbs which reduce the light to less than 6 per cent. Conifers are unable to survive and grow under such brush. Pulling and burning the undergrowth is being tried to study its effect on conversion possibilities. Cutting, breaking, and other methods of disposing of the undergrowth will be tried during the coming field season.

Studies of the effect of light and other factors on the growth of conifers under canopies are being carried out in an effort to determine the most satisfactory way to bring in reproduction under an old stand and escape severe competition from the old trees and secondary vegetation. A paper entitled "Does Light Burning Stimulate Aspen Suckers," now in press, shows that a light fire definitely stimulates the sprouting and growth of aspen suckers during the first season. A paper on "Light and Forest Growth" is now being prepared which shows a definite correlation between height growth of Norway pine and light intensity. Our efforts to improve field measurement of factors has led to the writing of a paper on "Light Sources and Light Measurement," recently submitted to Plant Physiology. The underlying principles of photometers, illuminometers, photo-electric cells and thermopiles are discussed, and the advantages and disadvantages of the various instruments pointed out. Thermopiles and other similar light measuring instruments are recommended as more desirable for ordinary field measurements than instruments whose sensitivity is confined to one spectral region only.

Renewed efforts on practical conversion methods will be initiated in cooperation with the Chippewa National Forest on the new aspen sale area. It is preposed to choose certain "islands" on which aspen appears to be less aggressive and plant these to conifers. One or more clearings will be made as required to bring the plantings up to such a height that they can successfully compete with other vegetation.

Reforestation Studies

In the general field of reforestation, apart from "tree breeding" studies, the principal developments during the past year have been the inception of a plan for comprehensive tests of methods, spacings, species and mixtures bearing upon the success of planting on the Huron National Forest; a tentative plan for the inauguration of a Federal planting project in North Dakota, and further progress in the stimulation of germination of white pine seed, so far entirely a laboratory study.

Planting Experiments - Huron National Forest

Small scale experiments, under way on the Huron for a number of years, have showed quite effectively, for example, that 2-0 seedlings are entirely adequate for the average conditions met there, and that planting can be done with almost equal success at any time from early spring to late fall, with the exception of the midsummer period. The matter of spacings has been determined not by any experimental results but according to theory and to meet certain factors extraneous to the forest itself. Mixtures have not been tried at all and there has been a growing tendency to plant Norway pine exclusively. The value of the native oak-brush cover has not been and could not be determined except through a long-term experiment. Under the less favorable conditions of 1927, 1929 and 1930 considerable losses have been taken in the younger plantations which leads to a questioning, for one thing, of the use of the comparatively undeveloped 2-0 seedlings. The experience during this period has indicated too, that native cover is a protection and not a detriment in drought periods. Different parts of the forest give decidedly different results during such a period, and cause us to pay greater attention to possible differences in the site conditions.

To meet all of these problems 4 experimental areas of 100 acres each to cover 4 discernible site conditions, have been laid out. On each of these areas 10 acres will be planted each year for the next 10 years. Within each 10-acre tract variations in spacing will differentiate 4 major subdivisions, and with each of the spacings different classes of stock, the comparative value of different species and their interrelations in mixtures will be tested. In the fall of 1931, when varied stocks will not be available to carry out all of these tests, the matter of spacing and the matter of the value of the brush cover will receive special attention, and the results of these tests may determine later procedure to some extent. For the entire area of the four blocks the species will be favored in the order Norway pine, white pine, jack pine and Scotch pine, but since one block is quite definitely a white pine site, this species will appear only spacingly in the other three.

Forest and Windbreak Planting in North Dakota

The possibility of a greatly increased forestry activity in North Dakota has come to realization through the efforts in Congress of Senator Nye. Increased appropriations will permit the Lake States Forest Experiment Station to carry on investigation and experiments in that region. The ground has been examined sufficiently to show that the most interesting possibility in the State is that of creating a federal forest on sandy lands comparable to the development in Nebraska which dates back to 1903 and is now on a very successful basis. It is hoped, however, to avoid the mistakes made in Nebraska by keeping this work on a strictly experimental basis, until the technical problems have been solved. It will then be time to consider the actual reforestation of the 100,000 acres or more of low-grade sandy lands in McHenry County, and possibly an equal area in Ransom and Richland Counties.

In addition to sandhill planting, North Dakota has her problem of farm windbreaks. The planting of farm windbreaks is proceeding slowly and effectively under the guidance of two public agencies, but a general planting campaign has not taken root with the farmers as a whole. This may be due to lack of appreciation of the benefits of windbreaks, or it may be in part lack of faith in the long-term success of tree planting, at least in those sections where the flat prairie is underlaid by hardpan. The experience in the older portions of the State and in South Dakota is certainly enough to make one skeptical, and it is believed there is no more important mission which the Lake States Station can perform, than to investigate these two questions, but particularly the question of soil conditions which may account for the early decadence of planted trees, and the possibility of removing or ameliorating these conditions before planting is done.

Seed Studies

In a more technical field, that of the general work of the Station on seed testing, and the subsidiary problem of germinating white pine seed promptly and fully, very substantial progress was made during the past year. Without enumerating various trivial improvements in seed testing, the discussion is confined to the white pine problem on which progress had already been made a year ago. The tests completed during the winter of 1929-30 showed convincingly that white pine seed can be brought out of its dormancy or "resting period" very fully by 30 days of stratification in moist sand at a temperature close to the freezing-point. A nursery trial of this method was made at Cass Lake in the spring of 1930, but either because the necessary physical conditions were not all met, or because the seed used was unusually ready to germinate in the spring without such treatment, only a slight effect from the treatment was to be noted in the germination of the different beds. This was in contrast to a jump from 25 to 30 per cent germination for untreated seed, to 95 per cent for treated seed under the more or less ideal experimental

conditions.

During the winter of 1930-31 a new series of tests has been made with stratification and with "dry" storage, not only to determine more exactly the limits of effective treatment as regards temperature and moisture, but also to provide material which could be examined chemically to afford an explanation of what happens within the seed to make it germinable. This is not only of general interest from the standpoint of plant physiology, but the more exact knowledge may suggest different lines of treatment which will be of still greater practical value. It is felt that this information will particalarly help in evolving storage methods, by which, in effect we hope to maintain the dormancy of the seed without any loss of its vitality. The fact that white pine seed deteriorates one-third in a period of two years under what we have thought almost ideal conditions, indicates that we have much yet to learn about the storage of this species. This fact has been brought out in another but related experiment.

In short, then, the current work implies not only a germination test on a given lot of seed after a given period of low-temperature treatment, but also an immediate chemical examination of the carbohydrates of the seed to determine, for example, to what extent its sugars have been increased or changed chemically. By correlating these changes with the changes in germinability, we hope to obtain an explanation of heretofore impenetrable secrets.

So far, the practical results of the treatments in moist sand are fully confirmatory of the results last year, although performed on an entirely different lot of seed. Temperatures from 32° to 50° F. are all about equally effective, as are also moistures percentages of 4, 8 and 12 in the sand, except that for the short period of 15 days the moisture absorption at higher content and temperature goes on a little faster and produces a better result at this stage. With longer treatment such differences disappear and it is believed the lower temperatures have somewhat better effect. There has been an almost imperceptible increase in the germination rate of seed stored for 30 days at low temperature with a very slight addition to their natural moisture, but it is too early to see how effective such a treatment may be.

In order to determine whether the peculiarity of slow germination of white pine seed might lie in the smaller and possibly less perfectly developed seeds of a given crop, a batch of seeds was graded by size and sown in the Cass Lake Nursery near the end of May, 1930. As judged by their relative germination in July and September, the smaller seeds were a little slower in getting to the surface than the large ones. However, their germination at the end of the summer was scarcely less, and while the small seeds produced small seedlings on the average, there is also so much variation in size among the seedlings of a large-seeded group that it can not be said that the small seeds, or even their late germination, are responsible in the largest measure for the wide variations in

seedling size which are common in white pine beds. Delayed germination in seeds of all sizes is responsible mainly, and therefore, not a great deal is to be gained by sifting out the small seeds. If delayed germination can be largely eliminated, then grading may be justified to create a still greater degree of uniformity in the beds, the small seed perhaps being sown separately and kept in the nursery a year longer. The best division is probably made between Grades 7 and 8, that is, by using a screen with 8/64" round openings.

Tree Breeding

As has been pointed out before, the primary purposes of tree breeding work is not to investigate obscure problems of heredity, but to answer the question: Within what limits may seed be collected for a given reforestation project; In view of the many failures of planting which may well be ascribed to the use of seed from a distant region, this is a matter which should be settled at the very outset.

Sources of Seed - Norway Pine

The greatest progress to date has been made in the study of Norway pine, because this is being more extensively used in the Lake States than any other conifer, and because seed grown on the remaining trees in the Lake States is in great demand for reforestation in the East. While this tree has a comparatively narrow range from north to south, and within this range does not seem to exhibit great variations in form or habit, yet there are undoubtedly "races" of Norway pine which have become adapted over a long period to the localities in which they are found. At least a suggestion of important differences in growth habit is seen in the 2-year-old trees from 41 different collections of seed, which are now growing in the Cass Lake Nursery. Perhaps equally important are the differences which appear in the progeny of individuals or small groups from the same general region, differences which are brought out by confining each seed collection to one tree or to small clumps, as far as possible. In the stock now growing at Cass Lake survivals varying from 8 per cent to 55 per cent of the number of seeds sown denote striking differences in the vigor of different stocks. In general, high vigor and survival in the seedlings is traceable to the passing of the greatest growth vigor in the parent tree. In other words, seed trees are to be avoided until they have naturally completed their greatest vegetative activity, or until this has been terminated through some extraneous factor. This does not imply that trees which are "scrubby" through any inherent characters are to be chosen as seed trees. In many instances it may be difficult to determine whether inherent characters enter in, but in most cases it is not difficult to see that a tree has merely reached maturity or has been "set back" by fires or similar factors.

In view of these individual differences, a considerable number

of tree samples are required properly to represent a region in the broader regional comparisons of tree stocks. Therefore, it was thought best in 1930 to expand the seed collections considerably, and there are now available 160 seed stocks which will be sown in 1931, grown in the nursery for two or three years, and at the end of that time set out in special plots on the Chippewa, Superior and Huron National Forests, and near St. Paul, these 4 planting sites covering quite well the growing conditions in the different parts of the range. Thus we may determine not only whether a given seed stock produces the best trees in its own native locality, but also in warmer and cooler localities and under different soil conditions.

Sources of Seed - Scotch Pine

Incidental attention has been given to the finding of a stock of Scotch pine suitable for the conditions of the Lake States, this foreign tree not only being widely used for ornamental and forest planting, but having some promise of being the equal of our native species if a form can be found which is well adapted to our climatic conditions. Such can not be said of most of the millions of Scotch pines which have been planted in this country heretofore. Several foreign importations of seed have been made, and these are under trial or will be put under trial in the future. The stock will be field tested in at least one set of plots of our own, and through cooperators.

Sources of Seed - Norway Spruce.

A similar situation exists with Norway spruce, a European species which generally grows much faster than our native spruces, and is apparently suitable for paper-pulp, but which is not thoroughly hardy, at least in our northern or spruce territory. That a hardy form can be found there is scarcely any doubt, but that this form may lack some of the outstanding growth vigor which is commonly associated with this tree also seems probable. It may prove best in the long run to put up with some injury and set-backs to young trees in order to have the better growth later on. If the trees "come out" of their injury, lack of complete climatic adaptation may not be a serious factor in a crop which will be harvested young, although it probably accounts for the decadence of most Norway spruce in this country after 30 to 50 years.

A thorough-going test of either white spruce or white pine from the standpoint of the Norway pine tests has not yet been started and must be postponed until the large amount of detailed work involved in the Norway pine study has been accomplished. However, it is deemed important to make a rather comprehensive test of the possibilities of spruce planting in the new national forest units of northern Wisconsin, and to this end it is proposed to grow considerable numbers of both white spruce and Norway spruce (of different origins) in the Rhinelander Nursery at once,

and in this way to obtain comparative tests of the two species and their forms while working out the planting technique suitable to different site conditions. In the case of the Norway spruce, as with Scotch pine, it is believed that inherent differences between the stocks of different origin are so great, that the most careful experimental conditions are not required to bring them out effectively.

Volume, Growth, and Yield Studies

Volume Tables for Second-Growth Norway Pine and Black Spruce

Volume tables, based chiefly on tree measurements obtained as a part of the study of volume and growth on cut-over lands in the Lake States, have been prepared for second-growth Norway pine and black spruce. A total fo 252 Norway pine trees were cut in Vilas, Oneida, and Bayfield Counties, Wisconsin, and used for the construction of volume tables in terms of total cubic feet, standard cords, and board feet, the last by the International (1/8-inch Kerf) and Scribner Dec. C rules. Also, a total of 239 trees of black spruce were measured in typical swamps in northern Minnesota and Wisconsin. In addition local volume tables were prepared for balsam fir, tamarack, basswood, black ash, hemlock, red maple, sugar maple, rock and white elm, and the existing volume tables for aspen, paper birch, jack pine, black spruce, northern white cedar were corrected and made applicable to understocked stands.

Application of Volume Tables to Poorly-stocked Stands

That taper, and consequently volume of trees, may vary with stocking was clearly shown by a sample of 218 aspen, paper birch, jack pine, and black spruce trees cut and measured in stands classified as poorly-stocked. The trees were relatively young and fast-growing, characterized by rapid taper and slender tops. The volumes of these sample trees were carefully computed and compared to the values given in previously prepared volume tables, which were gased on measurements of stands of decidedly better stocking. Trees from the understocked stands showed consistently lower volumes. On the average, the difference in volume was 6.5 per cent for aspen, 5.6 per cent for paper birch, 5.4 per cent for black spruce, and 1.7 per cent for jack pine. It has been concluded, therefore, that trees grown under poor conditions of stocking contain less volume than trees of the same diameter and height grown in well-stocked stands. When stands are sharply separated by density clasess, volume tables prepared for one density class should not be applied to another density class unless an applicability check has been obtained.

Planimeter Method vs. Smalian Formula

Before the planimeter method of computing cubic foot volumes had

been adapted in practice, trees were commonly scaled by Smalian formula on the basis of diameter measurements taken at 8-foot intervals. The accuracy of the Smalian formula is inversely proportional to the length of the section for which the volume is computed. When 8-foot sections are used, and no intermediate measurements are taken between the stump and diameter breast high, Smalian formula gives consistently higher volumes than the planimeter method. The difference between the two methods of computing volumes was found on the average to be 3.3 per cent for aspen, 6.2 per cent for paper birch, and 7.4 per cent for jack pine. In checking the applicability of old volume tables to actual volumes obtained by the planimeter method allowance should be made for this apparent discrepancy. Unfortunately, however, the difference between the two methods is not constant and depends, not only on the length of the section used in determining volumes but on the shape of trees as well.

Growth on Cut-Over Lands Registered Under the Wisconsin Forest Crop Law

In the summer of 1930 the Station, in cooperation with the University of Wisconsin and the Wisconsin Conservation Commission, conducted a preliminary study of growth on cut-over pine and swamp areas registered under the Forest Crop Tax Law of that State. The primary object was to obtain an inventory of the forest cover and to determine the rate of growth, actual and potential.

A total of 51 miles of survey strips were run through the sampled areas, comprising about 290 acres. The predominant types were aspen, birch, jack pine, and black spruce. Other types in order were northern hardwoods, swamp hardwoods, white cedar, Norway and white pine, and jack and red oak. Most of the stands, especially aspen and jack pine, were young and poorly stocked. Half of the material represented poor stocking. Seventy-six per cent of all stands were below 40 years of age and almost 90 per cent had trees below 7 inches in diameter.

This study will be completed early in 1931.

Forest Influences

Erosion in Southwestern Wisconsin

Work was continued in the erosion area of southwestern Wisconsin during the season of 1930. Traps were again placed in fields and forested slopes to obtain comparative data on the amount of run-off, much larger traps being used than in 1929, so that only once was their capacity exceeded. The small traps at all locations proved adequate for the small amounts of run-off from forest and brush land. Special attention was paid this year to the run-off from areas of the higher

table-land, whose run-off water often does considerable damage in getting down the steep slopes to lower levels. The data has not yet been compiled to see whether any new facts are brought to light.

Silt Content of Streams

More emphasis was placed in 1930 on the stream sampling begun late in 1929, observations being begun with the high water at the end of May and continued through to the end of October, with about 1000 samples taken from 17 streams. Owing to lack of effective rains the general average of silt contents was lower than in 1929, but there is as yet no basis for believing that the estimate of 15 million cubic yards brought into the Mississippi in this region from both the Wisconsin and Minnesota drainages, is too high. In addition to water samples to show silt content in suspension, traps were constructed and placed in several of the streams for a few weeks at a time, from which some very interesting data on bed-load movements were obtained. The movement in the Chippewa (a large stream) for example, was found to vary almost directly with the water depth, since this has a marked effect on the velocity at the bottom. From the data obtained the movement in this stream is estimated to be in the neighborhood of 15 cubic feet per day for each foot of width and for a normal discharge of about 8,100 second feet. This, with a width of 800 feet at the measuring point means 12,000 cubic feet per day, which is very considerably less than the suspended load.

The real secret of silt movements, it is apparent, can never be learned except by observations at peak heights. For example, on Buffalo River a single storm observation, out of approximately 32 observations made, accounts for more than 95 per cent of all the silt moved under observation, when both silt content and discharge of the stream at that time are considered. It is only at these extreme heads that silt gets to the Mississippi at an alarming rate. At the same time a good deal is deposited in the bed of the smaller stream, and it is the gradual removal of this material which comprises the load for the greater part of the yaer. Therefore, it is deemed very important in 1931 to start the observations early, to observe the spring peaks as far as the schedule will permit, and to provide some means of automatic sampling in case of high water occurring between the regular observations.

New Permanent Soil Erosion Station

It is the expectation that a permanent field station, in which the Forest Service, the Bureau of Chemistry and Soils, the Bureau of Public Roads and the University of Wisconsin will cooperate, will be established for the headquarters of the erosion work after July 1, 1931. The Federal government has made available $15,000 and the University of Wisconsin $10,000 for the conduct of the study during the fiscal year 1931-32. The details of the program, therefore, are held in abeyance

until organization plans are perfected. It is the feeling that this Station, when established, should plunge vigorously into the engineering and forestry features of erosion control on a fairly large scale. Interest in the possibility of controlling this destructive process as a public undertaking has been worked up to a considerable pitch, and seems to need only a few practical demonstrations to carry it "over the top" to some practical accomplishment. The problems which the individual farmer has to face should not be neglected, but to build on the theory that he, as an individual and in his present hard straits, is going to accept his responsibility and solve the erosion problem, merely means another generation of waiting for real results.

Proposed Studies

A number of other projects coming under the head of forest influences have been proposed for the Lake States, but can not be considered seriously until special funds are provided therefor. Among these are the control of erosion in the Badlands of North Dakota; a study of the flow of water from drained and undrained swamp lands; a study of the control of moving sand dunes on the west shore of Lake Michigan; and a lysimeter or tank study of the erosion of soils, to be combined with a study of their soil-water movement and their productivity.

During an examination of conditions in North Dakota a brief study was made of the possibilities of erosion control in the North Dakota Badlands. From the stand point of vegetation development, and even of forestry on a "protection forest" basis, the conditions are more promising than it was believed. That results from forest planting, and the improvement in other vegetation by banning grazing, would be too slow to have any effect on the condition of the Missouri River for many, many years is, however, obvious. It is, therefore, logical to suggest that when funds become available engineering means should be employed in the treatment of a small water shed experimentally to decrease the effects of present erosion, and in some cases to make the establishment of vegetation possible, where the soil is not at a stable gradient. This experiment could be developed later into a more elaborate "forest influence study".

The lysimeter study might possibly have been initiated with the emergency funds which have recently been provided, but in view, both of the mild winter and the uncertainty as to location of the erosion station, it was thought best to use these funds for other necessary improvements. The lysimeter plan involves taking out huge blocks of soil in a frozen condition, such as they have not been in this year.

Natural Classification of Forests on the Basis of Soils

The need for reasonably accurate statistics of the area and for a map of the location of forest types in the Lake States is basic to the

work of the Experiment Station and in fact to all forestry work in the region, whether economic or biological. The preparation of such a map or compilation of statistics of areas by actual surveys is a time-consuming and costly enterprise. An attempt has been made to develop short-cuts to obtain the necessary information, (1) by the use of road traverses supplemented by extensive forest type mapping from hills and lookout towers, and (2) by the use of soil maps and the relationships between forest and soil types.

It was found in actual trials of two different areas of 12 and 16 townships respectively that the direct mapping of forest types could be done at the rate of 2 to 3 townships per day and at a cost of about 1/10¢ per acre. This cost may be compared with that of the current forest surveys of 2 to 3¢ an acre. This method, however, is subject to serious objections in inaccessible parts of the region where roads are few. Even in counties relatively well supplied with roads, about one-fourth of the total area could not be seen and mapped directly. In the more northern and more sparsely settled parts of the region, the proportion would be considerably increased. The advantages are that locations of areas of forest types are obtained on maps at the same time with a means of computing acreages. Although the method is cheaper than other methods, the work still could not be accomplished for the region in less than 2 or 3 years at a cost of about $35,000.

The indirect method in which road traverses are supplemented by the forest and soil type relationships depends upon the maps and areas of soil types as determined by the soil surveys. These surveys have been carried on for the last twenty-five years and are available for about 10,000,000 acres or 20 counties in the northern part of the region. The relation established between forest types and soil types and its application in obtaining total areas of forest types may be illustrated by the following table for Ontonagon County, Michigan.

AREA OF FOREST TYPES

Ontonagon County, Michigan

Computed from percentages
of forest types on soil types.

Soil Type	Areas in 1000 acres	Norway Jack Pine	White Pine	Aspen	Hard-wood-Hemlock	Elm	White Spruce Balsam	Swamp
		Percentages of Soil Types						
Rubicon sand	65	3		64	29		4	
Roselawn stony sandy loam	58			46	52			2
Ontonagon fine sandy loam	26			45	53	1	1	
Porcupine loam	154			18	79		2	1
Ewen fine sandy loam	17			12	25	59	4	
Ontonagon silt loam	237			51	43	1	5	
Ontonagon clay	161		2	90	5	1	2	
Bergland clay	3			100				
Rough stony land	61			30	70			
Peat and muck	18			16	13			71
Total areas	800	3	3	400	344	14	21	15

The percentages of forest types applied to the total areas of soil types and totalled by forest types give the areas of forest types for the whole county.

That this indirect method gives reasonably reliable results, decidedly more accurate than the direct method, was shown by a check from the maps and statistics of the Michigan Land Economic Survey. The percentages of different forest types on each soil type in Roscommon County were applied to the total areas of corresponding soil types in Ogemaw County to predict the areas of forest types in the latter county. Comparison of the predicted with the actual areas gave a maximum difference of only 5 per cent of the total for two of the types and less than 3 per cent for all the others. The disdavantage of the indirect method is that, while it gives quite accurate figures for total acreage, it does not permit the definite location of forest type areas on a map. In other words, the method is suitable for statistics of forest areas but not for the preparation of a forest type map. The combination of the two methods enables the preparation both of reliable statistics and a partial map of forest type distribution at low cost.

On the basis of the field work done supplemented by such other information, like that of the state Economic Surveys, it was possible to make a more accurate evaluation of the acreages of forest types in the region than has heretofore been possible. These areas are shown in the following table.

AREAS OF FOREST TYPES
IN THE LAKE STATES

Forest Type	Michigan	Minnesota	Wisconsin	Regional Totals
	(All figures in 1000 acres)			
Aspen	5870	10900	5550	22320
Hardwood	4710	840	3600	9150
Oak	2970	2000	3580	8550
Jack pine	780	1500	1530	3810
Norway pine	35	170	90	295
White pine	45	100	130	275
Ash-Elm	1400	150	610	2160
Cedar-tamarack	2050	2150	510	4710
Spruce-balsam	190	1810	500	2500
Total forested area	18050	19620	16100	53770

Forest Economics

The Forest Survey

The forest survey, a part of the larger study of that name which is to cover the whole United States, was started in the Lake States in 1930. Work was on purely an experimental scale. As the appropriation was small no independent surveys were undertaken. Instead, arrangements were made to cooperate with the state land economic surveys.

These state surveys, in Michigan particularly, have prepared maps for a number of counties showing soil types, forest types, diameter classes and density of stands. But there has been need of some measure by which to translate these area determinations into terms of timber volumes and growth capacity. In order, therefore, to obtain more complete information, a three-man strip tally crew was attached to the type mapping crew in each state, the expenses being shared about equally between the states and the station. Altogether, some 600 miles of cruise lines were run at 3 mile intervals and fair samples of most of the common types were obtained. The additional data thus collected was sufficient to prepare a timber stand table representing an average acre of each important type which was mapped.

Forest Survey Plans for 1931

It is planned to continue the cooperative studies with the state land economic surveys in 1931 and to survey independently one or two separate areas in the region. Although the plan worked out in 1930 is generally satisfactory, for both state and national needs, only a relatively small percentage of the region has been mapped or can be mapped by the state economic surveys in time to meet the needs of the national forest survey. Even in Michigan where most progress has been made it is clear that some supplemental data will be needed in the southern part of the state.

It is hoped that Minnesota and Wisconsin will be in a position to join with the Station in making extensive and reasonably rapid surveys of their forest and land resources at an early date. It is with the idea of working out suitable methods for such an extensive survey that the independent work this year is contemplated. The plan is to pick out a suitable county and make an analyiss of its forest resources from strip surveys.

Aside from getting reliable information from strip surveys on acreage, timber stand, etc., an attempt will be made in 1931 to compile from all possible sources such reliable statistics as can be collected for a larger region. The Upper Peninsula of Michigan is considered suitable for such a study. Up-to-date figures for timber quantities and areas of forest types are not available for this region. The 1921 estimates

are known to be badly out of gear for some counties and probably for the region as a whole. From the standpoint of merchantable timber this is the most important section of the Lake States and inasmuch as it contains a large share of the remaining hemlock it is important as a source of pulpwood. It is a section in which industrial forestry has distinct possibilities.

The plan is to assemble such reliable figures as there are in the hands of county officials, to utilize the land economic survey maps for Chippewa, Alger, Luce, Menominee and Iron Counties and to get statements from the principal large timber owners on their holdings. This cannot be a complete section by section compilation but will suffice to give a general picture of the conditions in each county to serve the needs of the immediate future until more detailed field surveys can be made.

The need for a forest survey in a region like the Lake States, where the merchantable timber is practically at its end, may be questioned. The depletion may be true as far as sawlong timber is concerned, although there are still large areas of hardwood forests which play an important part in the hardwood supply of the country. But more important than figures on sawlog timber is the need for accurate information on the present and future pulpwood supplies of the region.

Approximately one-fourth of the U. S. paper and pulp industry is concentrated in the Lake States. Wisconsin is the second state in the Union in pulpwood consumption and Michigan is the second in paper production. The strength of the Lake States industry has been the high quality of its product based upon generous use of spruce, the favorable freight rate into the Chicago market plus a reasonably heavy local demand and the abundance of hemlock, a very cheap wood suitable for newsprint and other common papers. The plain facts of the present situation are that local spruce has almost disappeared in Wisconsin and Michigan, and hemlock is going fast. Even jack pine, superabundant not long ago, is hard to find in suitable sizes. The time is rapidly approaching when the industry will have to rely upon imported wood, which will take the edge off of its competitive advantage in the Chicago market, or adapt itself to local second growth. It is a matter of extreme importance to the leaders of this industry, therefore, to know not only the extent of the remaining old timber but also the extent, character and ownership of the reproduction and second growth and how fast it is coming on. Many companies are also interested in the growth capacity of different areas to produce pulpwood from plantations. These are matters which the Station will keep in mind in conducting its forest survey in the Lake States.

Reversion of Land to Public Ownership
The "New Public Domain"

Tax delinquency in the Lake States has constituted a serious problem for some time. The Forest Taxation Inquiry in 1926 and 1927 made a

general survey of the situation. The states through their economic surveys or Agricultural Experiment Stations, in addition, have made detailed studies of certain counties. Wisconsin has recently prepared a report on the situation in 17 northern counties. Minnesota has just checked up on the status of the land on a number of areas considered for state forests. Thus, the general situation as regards tax delinquency in the region is quite well known. But, there remains the need of developing a program and making a concerted effort to arrest the flow into public ownership of land suitable for private management and to make plans for properly caring for the areas which unquestionably are going to become a public charge.

The Station has been authorized to make a study in 1931 of the status of delinquency, the rate of abandonment, character of the abandoned land, what it is good for and who should take care of it. This is a very involved problem and the Station will seek the aid of state and local agencies to the end that all phases of the matter will receive adequate consideration and the results of the study can be put to immediate constructive use.

The abandoned land problem ties in closely with the forest survey project and to a large extent with the growth studies. One of the important questions in regard to tax delinquent land is: What is the real productive capacity of the land? This is important in determining how much tax such land can actually stand. It is important in figuring what kind of a yield tax arrangement will be equitable and how the counties and states will fare in such an arrangement. It is hoped that the present project for which a limited amount of federal funds are available will be the means of focusing the efforts of all interested agencies upon this phase of the problem. The federal interest exists not only in keeping this forest land productive but in the possibility that in the end a share of this land may have to be taken over by the federal government as national forest land.

Forest Biology

A study of the relation of animal and bird life of the Lake States to forest production was initiated in 1930. A small start was made on the general survey of invertebrate life in the region and some attention was given to the problem of natural and artificial regeneration on the Chippewa National Forest. Birds and rodents appear to be responsible for the loss of much of the natural crop of white pine seed and of young seedlings.

In addition to loss of seed, the destruction of young conifers by snowshoe rabbits reaches serious proportions. In fact, this is, perhaps, the most important of all forest biological problems in the region. During certain parts of the winter the snowshoe rabbits eat the tender terminal buds of the seedlings as they emerge from the snow.

Continued nipping of these branches and buds kill the larger percentage of the young seedlings and make ill-shaped and bushy appearing trees of the rest.

During 1931 the study of the relation of birds and rodents to reproduction in the Chippewa National Forest will be continued with special reference to the snowshoe rabbit problem. The survey of the animal population will also be continued, this to be carried on mostly on the Superior National Forest.

ALLOTMENTS AND EXPENDITURES

The allotments for the Lake States Forest Experiment Station for the last three years are as follows:

1928 $36,657.97

1929 $56,163.89

1930 $78,505.45

Distribution of Funds by Lines of Work

The distribution of the funds of the Station by lines of work for the last three years is shown in the following table:

	1928		1929		1930	
Botany			$ 433.30	.8%	$ 4,226.19	5.4%
Economics			1,075.72	1.9	10,277.95	13.1
Forestation	$ 6,221.93	17.0%	9,547.30	17.0	10,731.25	13.7
Influences	1,765.19	4.8	9,930.08	17.7	7,632.91	9.7
Management	14,412.29	39.3	17,468.03	31.1	15,494.64	19.7
Measurements	4,195.96	11.4	3,465.57	6.2	5,929.89	7.6
Protection	6,318.36	17.2	5,274.11	9.4	11,326.28	14.4
Tree Studies	57.30	0.2	17.35			
Type Studies	1,534.79	4.2	3,560.93	6.3	10,082.45	12.9
Public Service			3,937.75	7.0	2,621.10	3.3
Special Studies	2,152.15	5.9	1,453.75	2.6	182.79	0.2
	$36,657.97	100.%	$56,163.89	100.%	$ 78,505.45	100.%

Distribution of Funds by States

The expenditures of the investigative funds by states for the last three years is given below:

	1928		1929		1930	
Michigan	$11,617.91	31.7%	$22,029.10	39.2%	$32,835.45	41.83%
Minnesota	11,587.45	31.6	16,351.41	29.1	22,429.94	28.57
Wisconsin	13,452.61	36.7	17,393.02	31.0	22,415.06	28.55
North Dakota			390.36	.7	825.00	1.05
	$36,657.97	100. %	$56,163.89	100. %	$78,505.45	100. %

Expenditures for 1930

Including State Cooperating Agencies

	Funds of the Station		Cooperation		Total	
Michigan	$32,835.45	41.83%	$3,700.00	46.5%	$36,535.45	42.3 %
Minnesota	22,429.94	28.57	625.00	7.9	23,054.94	26.7
Wisconsin	22,415.06	28.55	3,625.00	45.6	26,040.06	30.1
North Dakota	825.00	1.05	--		825.00	0.9
	$78,505.45	100.00%	$7,950.00	100.%	$86.455.45	100.0 %

LAKE STATES FOREST EXPERIMENT STATION, ST. PAUL, MINNESOTA.
(Established 1923)

Permanent Personnel

Raphael Zon	Director
Carlos G. Bates	Senior Silviculturist
Joseph Kittredge, Jr.	Senior Silviculturist
Russell N. Cunningham	Forest Economist
J. A. Mitchell	Silviculturist
Francis H. Eyre	Silviculturist
Hardy L. Shirley	Associate Silviculturist
S. R. Gevorkiantz	Assistant Silviculturist
Clarence M. Aldous	Assistant Biologist
Edward L. Mowat	Junior Forester
Eugene I. Roe	Junior Forester
Paul O. Rudolf	Junior Forester
Harold F. Scholz	Junior Forester
LeRoy A. Holmberg	Junior Forester°
Philip McCandless	Junior Forester°°
John R. Neetzel	Junior Forester
Lawrence Zeleny	Agent
Mary A. Norton	Senior Clerk
Margaret H. Troop	Clerk-Stenographer
Hazel L. Stiles	Clerk-Stenographer
Evelyn J. McCandless	Jr. Clerk-Stenographer°
Mary Seaman	Jr. Clerk-Stenographer

°Resigned
°°Transferred.

Temporary Assistants During 1930

Robert T. Anderson
Clarence C. Averill
Russell A. Bonninghausen
Hjalmar Bruhn
Clarence D. Chase
Robert F. Collins
Ellery Foster
Hyman Goldberg
L. C. Hermel
Harry L. Hinkley
Eugene Izrael
Everett J. Jensen
Henning E. Johnson
Herbert A. Leitz
Thomas Lotti
Arnold C. Lomas
James H. McDonald
Harold J. Mitchell
Horold C. Moser
George T. Olsen
Jacob Ryerson
William L. Shetter
Phillip G. Spencer
Joseph Stoeckeler
Albert W. Sump
Roy A. Templin
Sergius A. Wilde
Ronald J. Woolery
Paul J. Zehngraff
Frances Moran
Ruth L. Vandewalker

Collaborators, 1930

Dr. Henry Schmitz
T. S. Hansen

ADVISORY COMMITTEE

Lake States Forest Experiment Station

Michigan

Dean S. T. Dana	University of Michigan
George R. Hogarth	Department of Conservation
P. S. Lovejoy	Department of Conservation
John M. Bush	Upper Peninsula Development Bureau

Minnesota

Dean W. C. Coffey	University of Minnesota
Grover M. Conzet	Conservation Commission
H. C. Hornby	Northern Pine Manufacturers Association
J. D. Twomey	Lumber Industry
C. L. Cecil	Pulp and paper industry

Wisconsin

Dean H. L. Russell	University of Wisconsin
Wm. J. P. Aberg	Izaak Walton League
W. A. Holt	Hemlock & Hardwood Manufacturers Association
Paul D. Kelleter	Department of Conservation
James B. Nash	Pulp and paper industry

Illinois

Dr. H. C. Cowles	University of Chicago